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SUMMARY

Comparison of Potential Poisons for Criticality Control for the Disposal of Weapons Pu in Immobilization Waste Forms

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This paper was prepared for submittal to:
American Nuclear Society
Criticality and Safety Division Topical Meeting
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Lawrence Livermore National Laboratory
Livermore, CA 94550

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Introduction

Disposal of weapons grade plutonium (Pu) presents a new challenge for criticality safety. DOE is developing a number of alternatives from which to choose one or more methods to dispose of about 50 MT of excess Pu from the down sizing of the nuclear weapons stockpile. One of these alternatives is the immobilization of Pu in a glass or ceramic waste form, followed by its permanent disposal in a geologic repository.

Criticality control is mandatory during all phases of the disposition process. This paper reports on work being done to assess the relative performance of potential neutron poisons used to maintain criticality control of glass and ceramic immobilization waste forms in their degraded states in a repository.

Various poisons are being considered for criticality control of Pu immobilization waste forms. While Gadolinium (Gd) at a poison to Pu mole ratio of one was the initial strawman choice; Hafnium (Hf), Indium (In), Europium (Eu) and Samarium (Sm) are also being evaluated. One, or a combination of these poisons may result in a more durable waste form, chemically allow the waste form to contain more Pu, be superior at staying with Pu and its U decay product as the waste form degrades, be neutronically superior, and be more cost effective.

Results

Results to date indicate that from both a nuclear and cost perspective, Sm is the better candidate neutron poison for criticality control.

This comparison is being done using representative monte carlo models of degraded glass and ceramic waste packages containing 339kg and 635kg of Pu each. With Gd at the nominal Gd to Pu molar ratio of 1, these degraded configurations are sub critical by a substantial margins, k-eff = 0.67 for the glass case and 0.78 for the ceramic case. The Gd is effective at keeping the systems sub critical. If the Gd is removed both systems are super critical, k-eff=1.17 for the glass case and 1.24 for the ceramic case. Standard deviations for these calculated k-eff values are all less than 0.004. The calculations were done using the 3d monte carlo code MCNP4B using continuous energy nuclear cross sections derived from ENDFB5, except for the poisons. Gd and Eu cross sections are from ENDL92, and for Hf, In and Sm from ENDFB6.

To provide the same level of criticality control in the glass case as Gd at a 1 to 1 Pu molar ratio, the following molar ratios of the potential poisons were determined:

Poison	Equivalent Poison to Pu molar ratio
Gd	1.0
Eu	0.28
Hf	1.7
In	2.2
Sm	0.64

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